Physics 152 Roster No.:_________________________

Due: Wednesday, November 23, 2005

Score:_____________________________

Take-Home Midterm Exam #3, Part A

NO exam time limit. Calculator required. All books and notes allowed, and you may obtain help from others. Complete all of Part A ***AND*** Part B.

For multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for). For fill-in-the-blank and multiple-choice questions, do you NOT need to show your work.

Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers.

Ignore friction/air resistance, gravity, and relativistic effects in all problems, unless told otherwise. Assume that all lenses and mirrors are ideally "thin" unless told otherwise.

Physical Constants: $c = 2.998 \times 10^8$ m/s

Conversions: It's an open-book test, so you can look them up!

1. (4 pts.) **Convert** the following quantities into the given units. Fill in the blanks. (You do NOT need to show your work.) Use *scientific notation* where appropriate (very large or very small values), and express all final values to *2 significant figures*.

a. 4.5×10^{-5} THz = ____________________ kHz

b. 3.0×10^{11} cm/s = ___________________ mi/h (miles/hour)

c. 1.5×10^{8} km/h = ___________________ ly/century (1 ly = 1 light-year = distance that light travels in one year in vacuum)

d. 550 nm = _________________________ Å (angstroms)

2. (4 pts.) **TRUE or FALSE (T or F)**:

______ Yellow light travels faster than green light in vacuum.

______ Yellow light has a higher frequency than green light in vacuum.

______ Ultraviolet light has a shorter wavelength than microwaves do.

______ Electromagnetic waves are "transverse" waves.

______ As light passes from air into glass, its frequency does not change.

______ As light passes from glass into air, its wavelength shortens.

______ The focal length of a lens depends on both (1) the material from which the lens is made, and (2) the curvature of its sides.

______ The focal length of a mirror depends on both (1) the height of the mirror, and (2) the mirror's radius of curvature.

3. (1 pt.) The index of refraction of *liquid water* is 1.33, while the index of *ice* is 1.29. Therefore, the **speed of light** in liquid water is __________ the speed of light in ice.

A. 3% faster than
B. 4% faster than
C. 5% faster than
D. 3% slower than
E. 4% slower than
F. 5% slower than
G. the same as

4. (1 pt.) Suppose that a particular type of glass is advertised as being *non-dispersive*. This type of glass could be used successfully in the manufacture of all of the following **EXCEPT** which one?

A. a converging lens
B. a diverging lens
C. a transmission diffraction grating
D. a prism used to spread incoming light into a spectrum

5. A beam of initially *un*polarized light first passes through polarizer *A*, then through polarizer *B*. Polarizer *B* can be rotated so that its axis forms an angle between 0˚ and 90˚ to the axis of polarizer *A*. (You do NOT need to show your work.)

a. (1 pt.) What **fraction** of the intensity of the initial unpolarized light is transmitted through polarizer *A*? _______

b. (2 pts.) Let I_1 be the intensity of plane-polarized light that passes through *A* and is incident on *B*. If only 15% of I_1 is transmitted through B, what is the **angle** between the axes of the two polarizers? __________

6. (2 pts.) Suppose that $n_{air} = 1.00$ and $n_{water} = 1.33$. Reflected sunlight is 100% polarized when it is reflected from a puddle at what **angle**? __________

7. a. (2 pts.) At what **distance** d_0 from a converging lens (focal length = 25 cm) should you place an object so that its image has a *magnification* of exactly –1? __________

b. (2 pts.) At what **distance** d_i from the lens will the **image** in part (a) be located? __________

c. (1 pt.) The **image** in part (a) will be located:

A. on the same side of the lens as the object
B. on the opposite side of the lens from the object

d. (1 pt.) The image in part (a) is...

A. upright and real
B. upright and virtual
C. inverted and real
D. inverted and virtual

Physics 152
Fall 2005

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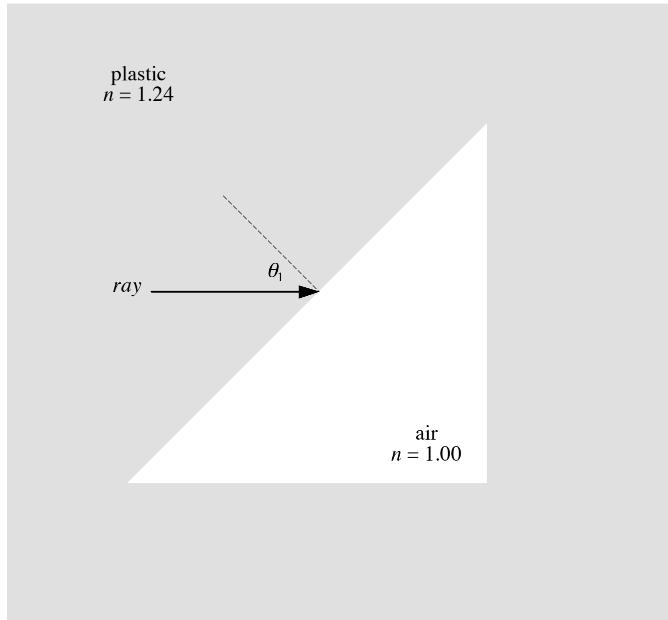
Take-Home Midterm Exam #3, Part B

1. A red laser beam (λ_{air} = 632.8 nm) traveling horizontally through clear plastic (n = 1.24) encounters an exact 45°-45°-90° triangular air gap (n = 1.00), as shown in the diagram at right.

a. (2 pts.) If the angle of incidence at the plastic-air interface is θ_1 = 45°, what is the **angle of refraction** $\boldsymbol{\theta_2}$ of the ray as it enters the air gap?



b. (2 pts.) Assuming that θ_1 = 45°, **draw** the continued path of the ray. Clearly show its bending due to refraction as it *both enters and leaves* the triangular air gap, continuing well into the plastic on the right-hand side. (Your angles need only be roughly correct, not measured precisely. *Use a straightedge!*)

c. (2 pts.) What is the **angle** of the *final* ray (in the plastic on the right-hand side) either *above or below the horizontal*? (You do NOT need to show your work.) __________

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d. (3 pts.) The first ray would have been totally internally reflected back into the plastic at the first interface if θ_1 had been greater than **what angle**, in degrees?

e. (1 pt.) What is the **name** given to the limiting angle you calculated in part (d)? ________________

2. a. (3 pts.) A beam of monochromatic yellow light passes through a transmission-style diffraction grating and heads toward a distant wall. Sharp bright *maxima* appear on the wall at angles of 0.0°, $\pm 10.0^\circ$, $\pm 20.3^\circ$, $\pm 31.4^\circ$, etc., away from the original beam direction. If the diffraction grating has 295 regularly-spaced "lines" (slits) per millimeter, calculate the **wavelength** of the yellow light, in **nanometers**.

b. (2 pts.) The many evenly-spaced planes of atoms in a crystal act like diffraction grating slits when they are illuminated with a beam of x-rays. (Examination of the resulting pattern is called "x-ray crystallography" and allows scientists to figure out the arrangement of atoms in the crystal. For the purposes of this problem, assume that the spacing between planes of atoms in the crystal acts just like the spacing between the lines of a diffraction grating, and hence follows the same equation. [This is not actually true in practice.])

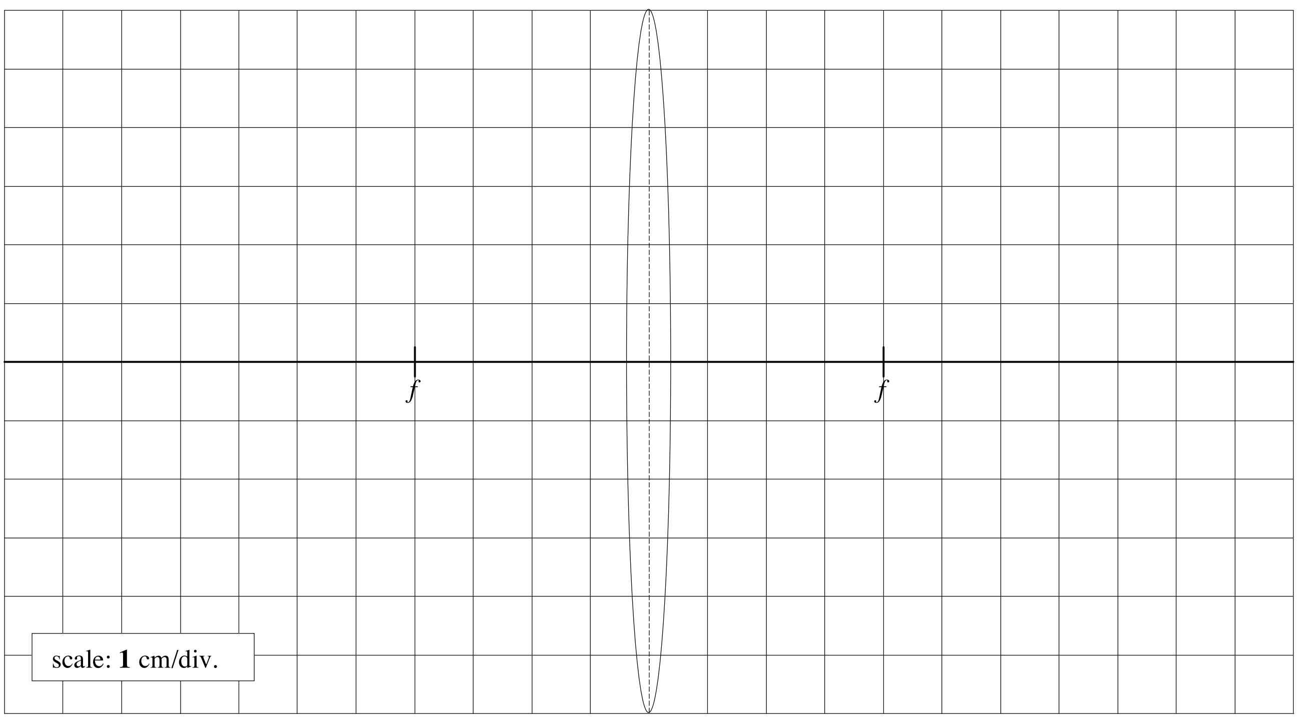
If you shine an x-ray beam ($\lambda = 0.110$ nm) on a crystal of table salt (NaCl) and observe that the *first-order maximum* of x-rays emerges at $\theta = 12.6^\circ$ from the direction of the incoming ray, estimate the **separation distance** between adjacent planes of atoms in the salt crystal.

3. You are using a magnifying glass to view a 1.0-cm-tall insect. The lens has focal length $f = 4.0$ cm, and the insect is 2.5 cm away from the lens.
a. (4 pts.) What is the **magnification** of the insect's image?

b. (1 pt.) The **image** of the insect in part (a) is…

A. real and upright
B. virtual and upright
C. real and inverted
D. virtual and inverted

c. (2 pts.) **Carefully sketch** the above situation to scale: each square = 1 cm on a side. **Draw and label** an **object** and an **image**, to scale. Draw all **3 principal rays** in your sketch.



d. (2 pts.) If you wanted to use the *same lens* to focus the Sun's rays to burn a hole in a sheet of paper (or in the insect, if you're feeling cruel), **how far** should you hold the lens from the paper? (*Hint:* assume the Sun is infinitely far away, so that rays of sunlight are parallel as they reach the lens.) **Justify** your answer either with a simple sketch *or* with a formula.

4. (5 pts.) A ray of light, initially horizontal, passes through a cylinder of glass of radius R, as shown. Assume that $n_{air} = 1.00$. Based on the geometry of the ray's path as shown, find:

a. the **final angle of the ray, θ_f**, with respect to the horizontal

b. index of refraction of the glass, n_{glass}